

**BEFORE THE
PUBLIC SERVICE COMMISSION
OF WISCONSIN**

Joint Application of Wisconsin Power and Light
Company and Wisconsin Electric Power
Company for Certificate of Authority for
Edgewater Generating Station Unit 5 NO_x
Reduction Project

Docket No. 5-CE-197

PRE-FILED DIRECT TESTIMONY OF

Paul Ireland

FOR

WISCONSIN POWER AND LIGHT COMPANY

October 20, 2009

1 **Q. Please state your name, employer and business address.**

2 A. My name is Paul Ireland. I am an Engineering Manager for URS Washington
3 Division (URS). My business address is 7800 E. Union Avenue, Denver,
4 Colorado 80237.

5 **Q. On whose behalf are you testifying?**

6 A. I am testifying on behalf of Wisconsin Power and Light Company (WPL).

7 **Q. Please summarize your education and professional experience.**

8 A. I received a B.S. Degree in Chemical Engineering from Syracuse University
9 in 1969. I have 30 years experience in air pollution control and 9 years
10 experience in engineering management. I have published approximately 50
11 technical papers on various aspects of air pollution control. Most recently I
12 was Manager of Process Engineering for URS Washington Division and I am

1 currently employed as an Engineering Manager with URS Washington
2 Division.

3 **Q. What are your responsibilities at URS Washington Division relative to**
4 **the Edgewater Generating Station Unit 5 NOx Reduction Project?**

5 A. As Manager of Process Engineering with URS, I oversaw URS's work on the
6 development of the Nitrogen Oxide emissions (NOx) control project for
7 Edgewater 5, including technology selection and cost development.

8 **Q. What is the purpose of your testimony?**

9 A. The purpose of my testimony is to:

- 10 1) Describe the proposed SCR technology
- 11 2) Describe the alternative NOx control technologies considered for
- 12 Edgewater 5
- 13 3) Explain the rationale for the selection of SCR control technology
- 14 4) Provide the cost estimate for the proposed project

15 **Q. What are the current operating conditions at the Edgewater Generating**
16 **Station Unit 5?**

17 A. Edgewater Unit 5 is one of three units that comprise the Edgewater
18 Generating Station. Edgewater Unit 5 is a wall-fired boiler that currently runs
19 at a gross maximum operating load of 430 MW and was retrofitted with low-
20 NOx burners (LNB) and separated over-fire air (SOFA) technologies to
21 reduce NOx emissions. Unit 5 is equipped with cold-side electrostatic
22 precipitators (ESP) for particulate emissions control.

1 **Q. What are the current operating conditions at the Edgewater Generating**
2 **Station Units 3 and 4?**

3 A. Edgewater Units 3 and 4, the other two units at the Edgewater Generating
4 Station, are cyclone boilers with generating capacities of 70 MW and 325
5 MW, respectively. These units were retrofitted with selective non-catalytic
6 reduction and Rich Reagent Injection (SNCR/RRI) systems to reduce
7 emissions of nitrogen oxides (NOx). Units 3 and 4 are also equipped with
8 cold side ESPs for particulate control.

9 **Q. What level of NOx reduction has been achieved at Edgewater 5 with the**
10 **combination of low-NOx burners and over-fire air?**

11 A. The application recognized that the installation of low NOx burners and
12 separated overfire air has reduced NOx emissions from Edgewater 5 by 31%,
13 from a baseline of 0.229 lb/MMBtu to 0.160 lb/MMBtu, which was the
14 reduction seen at the time of the application. The latest data from Edgewater
15 5 for the summer of 2009 show an average NOx emission of 0.143 lb/MMBtu
16 for the SmartBurn technology installed.

17 **Q. What level of NOx reduction is required for Edgewater 5?**

18 A. To enable compliance with RACT Phase II requirements using a unit-by-unit
19 compliance approach, a NOx emissions rate from Edgewater 5 of 0.10
20 lb/MMBtu or less is required. To enable compliance with RACT Phase II
21 requirements using a facility-wide averaging approach, a NOx emissions rate
22 from Edgewater 5 of approximately 0.08 lb/MMBtu or less is required. If one
23 includes a compliance margin of approximately 10%, then the required NOx

1 emission rates drop to 0.09 and approximately 0.06 lb/MMBtu respectively.
2 Achieving 0.09 and 0.06 lb/MMbtu NOx emission rates require Edgewater 5
3 to reduce emissions by 43.75% and 62.5% respectively from a beginning
4 emission level of 0.16 lb/MMBtu.

5 **Q. What NOx emission control technologies exist and what levels of**
6 **reduction can they achieve?**

7 A. NOx reduction technologies are generally divided into two categories:
8 primary (also referred to as combustion control methods) and secondary (post-
9 combustion control methods). Primary control methods, such as boiler tuning,
10 low NOx burners and overfire air, alter the combustion process to limit the
11 formation of NOx in the combustion process. These technologies are
12 generally limited to 10-35% reduction.

13 Secondary technologies, such as selective non-catalytic combustion
14 (SNCR) and selective catalytic reduction (SCR) reduce NOx after it has
15 formed. The NOx reduction potential of SNCR and similar technologies that
16 inject reducing reagents into the boiler is typically in the range of 25% to
17 30%. SCR provides the greatest opportunity for NOx reduction with systems
18 designed to achieve up to 90% removal efficiency. Primary and secondary
19 control technologies can be used in combination to provide varying degrees of
20 NOx reduction.

21 **Q. Could you summarize the NOx control technologies considered along**
22 **with their expected removal efficiencies at Edgewater 5?**

1 A. URS Washington Division was contracted by WPL to conduct an assessment
2 of possible NOx reduction technology to be installed on Edgewater unit 5 to
3 comply with RACT requirements. The study considered NOx control
4 technologies as described in Section 6 of the CA document, including SNCR,
5 RRI, Hybrid SNCR/SCR, and full-size SCR. The table shown below
6 summarizes these candidate NOx control technologies and their expected
7 stand alone removal efficiencies.

8 *Candidate NOx Reduction Technology Removal Efficiencies*

NOx Reduction Technology	NOx Removal Efficiency
Rich Reagent Injection (RRI)	30% ^a
SNCR	25%
Hybrid SNCR/SCR ^b	55%
Full-size SCR	90%

9 a. 30% is applicable and achievable on cyclone boilers only, not on Edgewater 5.

10
11 b. Hybrid SNCR/SCR removal efficiency stated in this table assumes a uniform distribution
12 of ammonia reagent to the SCR catalyst.

13
14 As previously mentioned, Edgewater Unit 5 currently operates Low NOx
15 Burners (LNB) and Separated Overfire Air (SOFA). In order to meet RACT
16 Phase II requirements, regardless of whether a unit-by-unit or facility-wide
17 averaging approach is used, the URS Washington Division study concluded
18 that the only commercially proven technology that can reliably and
19 consistently achieve the minimum removals needed (43.75% or 62.5% from a
20 0.16 lb/MMBtu beginning emission level) on a long term basis is a full-size
21 SCR.

22 **Q. Could you explain the proposed SCR technology?**

1 A. The technology proposed for control of NO_x emissions at Edgewater 5 is a
2 Selective Catalytic Reduction (SCR) system. In an SCR system, ammonia is
3 injected in the flue gas, where it reacts with NO_x to form nitrogen gas and
4 water. The reaction between ammonia and NO_x is facilitated by a catalyst,
5 hence a “catalytic” system. An SCR system is typically located between the
6 economizer and air heater, where the flue gas temperature is optimal for the
7 catalyst, allowing the SCR system to achieve high NO_x removal rates.

8 An SCR system retrofit on a coal plant involves installation of the
9 following major components: the reactor, which contains the catalyst;
10 associated ductwork carrying flue gas to and from the reactor; an ammonia
11 storage tank or an alternate source of ammonia; piping and valves associated
12 with ammonia injection into the flue gas; and air heaters/blowers for
13 conveying ammonia to the flue gas at the correct concentration. Often times,
14 as is the case for Edgewater Unit 5, a water solution of ammonia is used
15 (aqueous ammonia), because it is less hazardous than the pure form of
16 ammonia, which is typically handled as a compressed/liquefied gas
17 (anhydrous ammonia). Where aqueous ammonia is used, ammonia vaporizers
18 are also necessary to heat and evaporate the aqueous ammonia solution.

19 **Q. Is SCR considered a commercially proven technology?**

20 A. SCR has by far been the most widely applied technology for NO_x technology
21 in both the US and worldwide. In the US alone, there are over 100 GW of
22 operating SCR installations.

23 **Q. What level of NO_x reductions can be achieved by this technology?**

1 **A.** SCR systems have demonstrated up to 90% removal of inlet NO_x from the
2 flue gas with a lower removal limit of 0.04 lb/MMBtu when applied to a coal-
3 fired boiler.

4 **Q.** **Are there alternatives to the proposed project that can achieve similar**
5 **reductions?**

6 **A.** No. The hybrid SNCR/SCR is the next most effective NO_x reduction
7 technology with an estimated removal efficiency of 55%. Further, its lack of
8 commercial experience on units as large as Edgewater 5, and the operating
9 issues that have been seen with the in-duct catalyst (a lower cost design
10 configuration for the hybrid technology) indicate that this technology would
11 also pose significant risks in terms of its ability to achieve guaranteed removal
12 efficiencies over long term operation.

13 **Q.** **Can you explain the hybrid technology?**

14 **A.** The hybrid SNCR/SCR combines two technologies for NO_x control. It
15 consists of ammonia or urea injection into the boiler (typical of a selective
16 non-catalytic reduction system, SNCR) and a small SCR catalyst installed
17 between the boiler and the air heater in the existing ductwork. The ammonia
18 that has not reacted with NO_x in the boiler will then react with NO_x within
19 the catalyst bed, thus achieving higher removal efficiency than is possible
20 with SNCR alone.

21 **Q.** **Is the Hybrid SNCR/SCR technology considered a commercially proven**
22 **technology?**

1 **A.** No, I am aware of only two installations of this technology, one of which has
2 since been decommissioned.

3 **Q. Was Hybrid SNCR/SCR considered as an alternative?**

4 Yes. The Hybrid SNCR/SCR technology was considered, but was not chosen
5 due to its inability to achieve the NO_x removal requirement, its potential for
6 high ammonia slip, and its lack of commercial experience.

7 **Q. Would Rich Reagent Injection (RRI) work at Edgewater 5?**

8 **A.** No. RRI was developed specifically for cyclone boilers and requires injection
9 of ammonia or urea into a sub-stoichiometric, fuel-rich area of the boiler, with
10 no oxygen availability. While this oxygen deficient area exists in a cyclone
11 boiler, it does not exist in a pulverized coal fired boiler due to reduced mixing
12 and increased stratification of the air and fuel streams, compared to a cyclone
13 boiler. Discussions with staff at Reaction Engineering International, the
14 developers and patent holders on the RRI technology, confirmed that RRI
15 technology is not a proven technology for pulverized coal fired boilers, has
16 only been tested on a small pilot scale pulverized coal fired boiler and no
17 further development is planned for pulverized coal fired boilers such as
18 Edgewater 5.

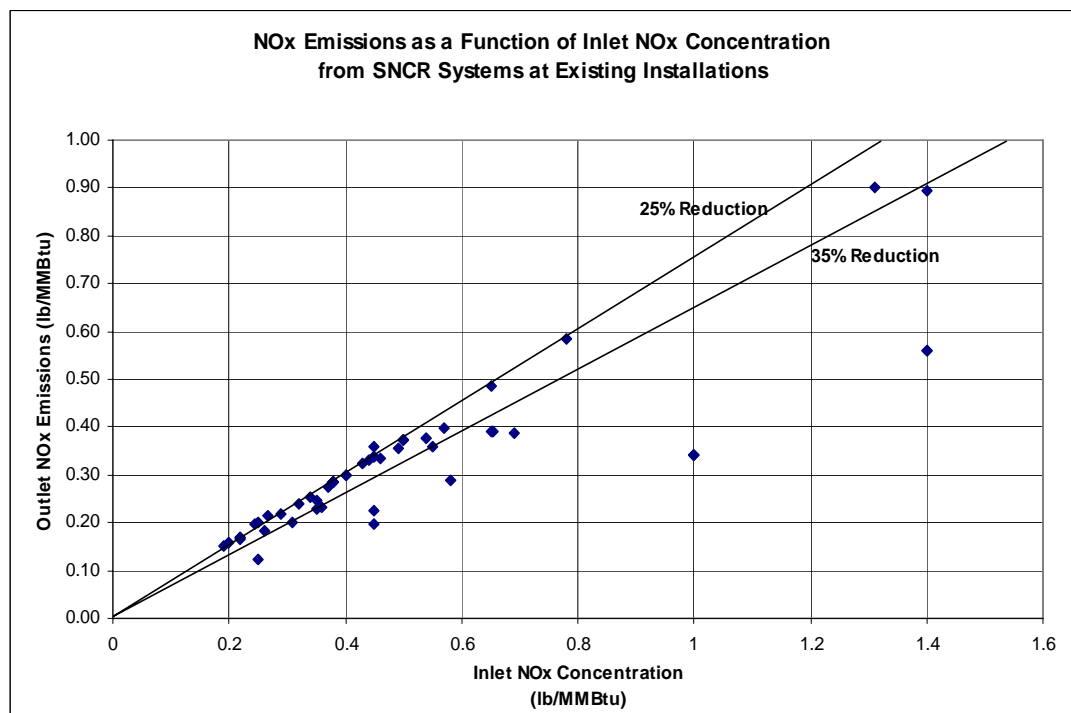
19 **Q. Did you consider a combination of SNCR/RRI, similar to technology**
20 **installed on Edgewater 3 and 4?**

21 **A.** No. For the reasons stated above, RRI would not work on Edgewater 5,
22 which is a pulverized coal fired boiler. Although SNCR/RRI has been

installed on Edgewater units 3 and 4, both of these units are cyclone fired boilers, for which the RRI technology was developed.

Q. Was SNCR considered?

A. Yes, SNCR was considered. Experience with SNCR would indicate about a 25-35% reduction of NO_x, not sufficient to meet the 43.75% or 62.5% reduction requirement (based upon a starting emission rate of 0.16 lb/MMBtu) for Edgewater 5. The following graph shows a cross-section of existing SNCR installations; none of which have demonstrated removal below 0.10 lb/MMBtu and generally show removals of 25-35%.



¹ Data extracted from ICAC white paper entitled "Selective Non-Catalytic Reduction (SNCR) for controlling NO_x Emissions" February 2008

Q. What is the current performance of the combustion controls installed on Edgewater 5?

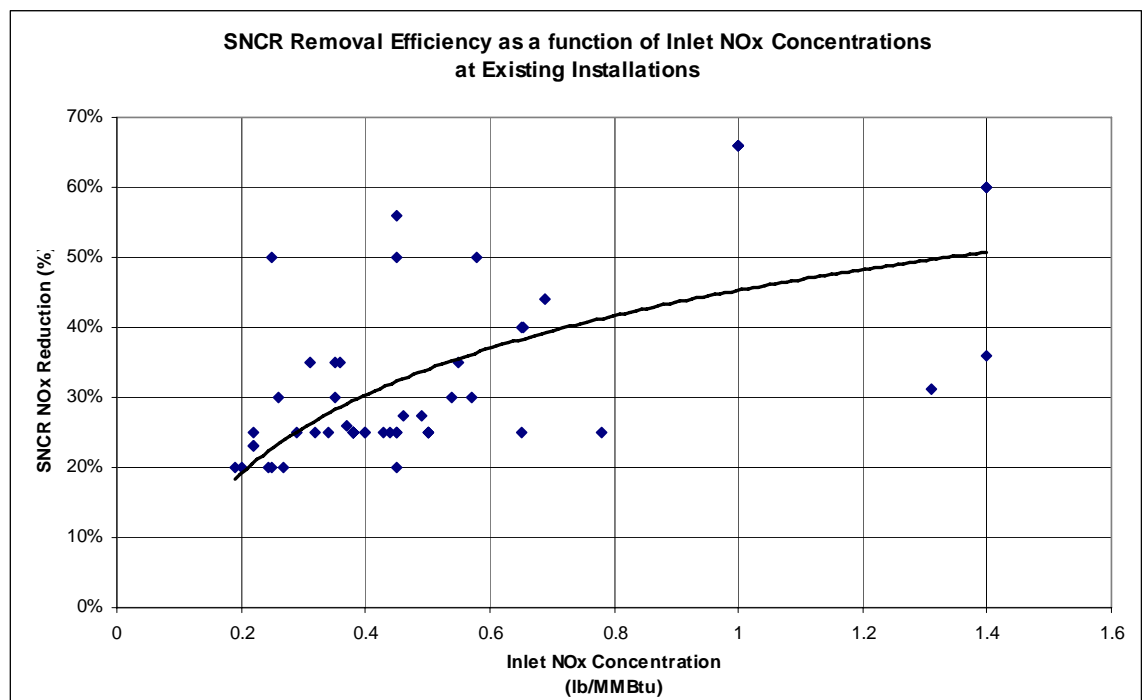
1 A. As noted previously, the latest data from Edgewater 5 for the summer of 2009
2 show an average NOx emission of 0.143 lb/MMBtu for the SmartBurn
3 technology installed, which is a combination of low NOx burners and
4 separated overfire air. Note that this performance is somewhat better than the
5 level of 0.16 lb/MMBtu reported in the Certificate of Authority Application in
6 November 2008 and which was seen at the time of the Application.

7 **Q. Based on this better performance, could SNCR be used to achieve an**
8 **outlet NOx concentration of 0.10 lb/MMBtu?**

9 A. No. There is a critical level of NOx below which NOx cannot be further
10 reduced by SNCR. For typical coal fired boilers, the critical NOx level is
11 considered to be 0.10 lb/MMBtu (SNCR for controlling NOx Emissions,
12 Institute of Clean Air Companies, February 2008). As long as the initial NOx
13 level is above the critical NOx level, NOx reduction can be achieved.
14 However, as the NOx critical level is approached, SNCR NOx reduction
15 performance degrades. EPRI has observed SNCR process performance
16 degradation at initial NOx levels less than 0.14 lb/MMBtu. (EPRI report
17 1004727 of November 2004)

18 Projected SNCR performance solicited by URS from a major SNCR
19 technology vendor predicts a 17.5% reduction in NOx for a coal fired boiler
20 with an initial NOx level in the same range as Edgewater 5. For Edgewater's
21 current NOx level of 0.143 lb/MMBtu, this 17.5% reduction would result in a
22 NOx emission of 0.118 lb/MMBtu, still 18% higher than the required 0.10
23 lb/MMBtu level.

The limitation of the critical NOx level and the observance of SNCR performance degradation also explain why there are no data on the above graph that show SNCR applied to any units with NOx inlet concentrations below about 0.20 lb/MMBtu. Also note on the above graph that SNCR has achieved only one outlet NOx concentration below 0.15 lb/MMBtu (0.12 lb/MMBtu at one installation). Thus, I am aware of no evidence or performance at any existing SNCR installation that would support SNCR being able to reduce the NOx level at Edgewater 5 from its current NOx level of 0.143 lb/MMBtu to a level of 0.1 lb/MMBtu.



¹ Data extracted from ICAC white paper entitled "Selective Non-Catalytic Reduction (SNCR) for controlling NOx Emissions" February 2008

Q. What is the estimated cost for the proposed project?

A. The estimated cost for the proposed project is \$154 million, which includes all costs except allowance for funds used during construction (AFUDC).

1 **Q. What is the basis for the cost estimate?**

2 A. URS Washington Division developed capital and operating and maintenance
3 cost estimates for the Edgewater Unit 5 SCR project. The total project
4 estimate includes the following major items:

- 5 • Civil, Structural and Architectural items (including foundations,
6 support and structural steel, and flue gas ductwork)
- 7 • Mechanical and process related items (SCR systems, ammonia
8 storage and transfer systems, process piping, fire protection, and
9 balance of plant mechanical systems)
- 10 • Electrical systems (including auxiliary power distribution, lighting,
11 grounding, heat tracing, and the construction power system)
- 12 • Instrumentation and Controls (including DCS integration into
13 existing system and local instrumentation and controls)
- 14 • Engineering fees, construction management, and start-up services
15 (including commissioning and performance testing).
- 16 • Owner's costs

17 Costs represent URS' estimate, prepared in January 2008, with WPL's
18 project specific owner's costs, cost of spare equipment, contingency, and
19 insurance expenditures. The cost estimate has an accuracy of -5/+15%. As
20 detailed design and engineering work progresses, project cost estimates will
21 be refined.

22 The estimated capital cost for the Edgewater Unit 5 SCR is provided in
23 Table 1 of the Certificate of Authority Application, which is reproduced

below. These costs do not include Allowance for Funds Used During Construction (AFUDC).

Table 1. Edgewater Unit 5 SCR Estimated Capital Cost

Description	Cost (\$)
SCR Reactor Housing and Installation	\$21,209,000
Ammonia Handling and Injection	\$873,000
Miscellaneous Equipment/ Spares/ Balance of Plant	\$15,184,000
Ductwork Modifications	\$6,110,000
General Facilities	\$4,585,000
Indirects	\$8,449,000
Craft Labor/Installation	\$20,695,000
Engineering/Construction Management/Start-Up	\$14,756,000
Sub-Total	\$91,861,000
Contingency	\$20,104,000
Escalation	\$14,695,000
Sub-Total	\$34,799,000
Prime Contractor's Markup	\$10,898,000
Owner's Costs	\$16,386,000
Total Project Cost	\$153,944,000

Q. What effect would market fluctuations have on the cost estimate since its original development in January, 2008?

A. The cost estimate for the proposed project was developed in January 2008 and there have been market fluctuations in various components since that time. In the intervening 21 months (as of this writing in October 2009), steel prices have decreased 5-8%, construction labor has increased about 2%, equipment has increased about 1%, while other commodities (concrete, pipe, electrical, instrumentation, etc.) have stayed steady. We would judge the net result of these market fluctuations to be offsetting and would consider this estimate to

1 still be valid today, and would assign the same level of estimate accuracy as
2 the original cost estimate.

3 **Q. How does the capital cost for Edgewater 5 SCR compare to other recent**
4 **SCR projects?**

5 A. The cost estimate of \$154 million for this proposed project is equivalent to
6 \$358/kw, which is the standard metric used to compare costs between plants.
7 Several other recently announced or recently completed projects were used for
8 comparison. These other SCR projects show that the cost estimate for
9 Edgewater 5 SCR project is reasonable and in-line with these other projects.
10 These projects and their cost estimates include:

11	Wisconsin P&L Edgewater 5	\$358/kW
12	Kentucky Utilities E. W. Brown 3 ¹	\$412/kW
13	Wisconsin Electric South Oak Creek 5-8 ²	\$444/kW
14	East Kentucky Power Coop Cooper 2 ³	\$332/kW

15 **Q. Does this conclude your pre-filed direct testimony?**

16 A. Yes.

¹ Case No. 2009 -00197 Kentucky Public Utility Commission Testimony of John Voyles June 26, 2009, page 50, capital cost of \$184 million, 446 MW, start date 2013

² WEPCo Application to Install FGD and SCR on Oak Creek 5-8 for Control of SO₂ and NO_x June 15, 2007 (Site/balance of plant/site prep/demolition allocated pro rata to FGD and SCR cost. Cost excludes AFUDC), capital cost \$504 million, 1135 MW, 2013 start date

³ Application of East Kentucky Power Coop for a certificate of Public Convenience and Necessity for the Construction of an Air Quality Control System at Cooper Power Station, Case No 2008-00472 November 14, 2008 (507 pages), \$59.4 million (2007\$) escalated for 6 years at 3.5% escalation = \$73 million, 220 MW